TECHNICAL SUMMARY

STUDY TITLE: Environmental Investigation of the Use of Shoals Offshore Delaware and Maryland by Mobile Benthos and Finfish Species

REPORT TITLE: Comparisons Between Marine Communities Residing on Sand Shoals and Uniform-Bottom Substrate in the Mid-Atlantic Bight

CONTRACT NUMBER: MMS 1435-01-02-CT-85060

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BACKGROUND: Many of the beaches along the Mid Atlantic Bight (MAB) are undergoing long-term erosion due to sea level rise, human activities, and from severe coastal storms. In efforts to try to restore beaches lost to erosion various state and federal governmental agencies have ongoing or proposed beach stabilization projects that require significant sand resources to complete. As the need to replenish beaches increases new sand resources will be required and those will likely be taken from federal waters. The Minerals Management Service (MMS) has jurisdiction over all mineral resources occurring in federal waters. The MMS along with both Maryland and Delaware Geological Survey have identified four specific sand shoals off of their coasts as potential resources for long-term sand mining. The specific shoals are, Shoal B, Shoal D, Fenwick Island Shoal, and Weaver Shoal. If shoals provide important habitat to specific marine communities, then mining activities could have negative impacts to those communities,

and before mining can occur, information must be gathered pertaining to what species of fish and mobile benthos may be affected by mining.

OBJECTIVES: The main objectives of this study were to 1) determine what species of fish and mobile benthos reside at offshore sand shoals, and 2) evaluate if the shoals represent important habitat for those species. The focus of this study was to compare the four sand shoals to four reference habitats located in the same region that exhibited similar macro and microhabitat features, but did not exhibit vertical relief like the shoals. To evaluate if shoals are important habitat, we compared species abundances and diversity between the four shoals and four reference habitats. Species abundance and diversity were used as determinants of habitat quality and we defined an area to be "preferred" if total species or communities occur at greater abundances and higher diversities within that area.

DESCRIPTION: The study was located on the inner continental shelf of the MAB region off the coast of Maryland and Delaware. The primary focus was four sand shoals; shoal B, D, Fenwick, and Weaver, and four flat-bottom reference sites. The shoal and reference areas were located between 16 and 25-km off the coast and encompass approximately 800 square km of the inner shelf.

A randomized paired site design was used to compare the distribution, total relative abundance, and diversity of finfish and mobile benthos species residing on the shoals and nearby uniform-bottom habitat. Four pairs of sites were established by pairing each of the four shoals to a specific uniform-bottom reference site. To identify comparable reference sites and to quantify species and community abundance three specific methods were used. Initially, underwater video technology was used to identify and characterize reference locations in proximity to the shoals. Then four reference sites were chosen based on similarities of physical and biological micro and macrohabitat features that were present at those sites and the shoals. Once the sites were identified, then a multi-year comprehensive fisheries study consisting of daytime trawling, gillnetting and nighttime bioacoustics was employed to compare and contrast the relative abundance, diversities and distribution of fish and mobile benthos communities between the shoals and flat-bottom reference sites.

A total of 41,893 individuals were collected from a combination of 384 small trawl (n=128), commercial trawls (n=128) and gillnet sets (n=128) that were conducted for two consecutive years. In the collections there were 57 species of fish including 15 species of sharks, skates, and rays. In addition, there were 17 invertebrate species represented by 7 decapod crustations and 10 other invertebrate species. Comparisons between catch per unit effort (CPUE; relative abundance), species richness, and diversity were performed between shoals and reference sites for each season and gear using the Analysis of Variance tests (ANOVA). There were mixed results with generally higher numbers of total species abundance, total species richness, and total species diversity at the reference sites in trawls and no clear patterns in gillnet data. There were significant seasonal differences in species densities throughout the study at all the sampling sites and between all gears. There were also differences in catch between all gears within a season.

Comparisons of specific species guilds using ANOVA were also done on site pairs. The analysis was performed for each combination of gear and guild except pelagic invertebrates in gillnets. For this study we defined a guild based on feeding strategies found in the literature, such as primarily benthic oriented feeding or pelagic feeding strategies. Four functional groups or guilds were defined from the fisheries data: benthic finfish, benthic invertebrates, pelagic finfish, and pelagic invertebrate. Analysis of specific species guilds show that more benthic finfish, pelagic finfish, and pelagic invertebrates (squid) were captured in the commercial and small trawls at reference sites than at shoals. The difference was statistically significant at $\alpha = 0.05$ for all of these comparisons except benthic finfish in the commercial trawl, which had $\alpha = 0.058$ level of significance. Each of the trawl gears captured benthic invertebrates in nearly equal numbers at shoal and reference sites. Capture rates in gillnets differed from those in trawls. In gillnets, all assemblages except pelagic invertebrates were captured in about equal numbers, and no significant differences were detected. No pelagic invertebrates were captured in gillnets.

Meta-analysis of the trawl gears confirmed that benthic finfish, pelagic finfish, and pelagic invertebrates occurred in greater densities at reference sites than at shoals. The standardized difference in mean transformed densities was about 0.5 standard deviations for all three assemblages, and 95% confidence intervals indicated the difference was probably at least 0.2 standard deviations for all three guilds. There was little evidence that benthic invertebrate density differed between shoal and reference sites, as indicated by the small standardized difference between mean densities (0.01 standard errors) and associated 95% confidence interval that intersected zero by a large amount.

For all three gears, there was strong separation of sites according to season in cluster analysis. Shoal and reference samples collected with the small trawl showed a tendency to form groups in spring and summer, but not in fall or winter. For the commercial trawl samples, there was a tendency for shoal and reference samples to group in summer, a clearer pattern of separation in fall and winter, and no pattern in spring. No structure existed for the gillnet samples that would suggest differences between the shoal and the reference sites. Two-way crossed ANOSIM tests detected a significant difference between sites for the commercial trawl data, a difference at the 10.9% level for the small trawl, and no difference for the gillnet data. For the commercial trawl, an observed value of R of 0.18 is a very unlikely event and leads to the rejection of the null hypothesis at the 0.1% level. For the small trawl, a significant difference can be inferred given that only a relatively small number (10.9%) of the simulated R values is larger than the observed R of 0.06. Season was highly significant for all tests.

The results of the two-way crossed ANOSIM tests suggest that despite the strong effects of season, differences in species composition between the shoal and the reference sites could be interpreted for the small trawl and commercial trawls. SIMPER was then used for these two gears to determine which species typified the shoal and the reference sites. For the commercial trawls, striped bass and several other species more equally contributed to the separation between shoal and reference sites in the fall; winter skate, windowpane, and little skate contributed most in winter; scup, butterfish, and squids in the spring; northern searobin, scup, and squid in the summer. Many species contributed

to the discrimination between the shoal and the reference sites, but none better than scup in the fall, winter skate in winter, and northern searobin in summer. All three fish species were more abundant in the reference than in the shoal sites.

Six seasonal bioacoustic surveys in all seasons but winter were conducted at each pair of sites over the two year study. Analysis of bioacoustic data was conducted using ANOVA with mean Sv (relative fish biomass in decibels) and fish density (number/10,000 m^3) and variables. In general, fish densities and biomass fluctuated between sites throughout the seasonal surveys. Differences between individual shoals and their reference sites were found in many seasons and some patterns are evident within site pairs.

In summary, comparisons between shoals and reference sites for each season and gear showed mixed results with generally higher numbers of total species abundance, species richness, and species diversity at the reference sites in the trawl data and no clear patterns in gillnet data. There were significant seasonal differences in species densities throughout the study at all the sampling sites and between all gears. There were also differences in catch between all gears within a season. Analysis of specific species guilds showed that more benthic finfish, pelagic finfish, and pelagic invertebrates (squid) were captured in the commercial and small trawls at the reference sites compared to the shoals. In gillnets, all guilds except pelagic invertebrates were captured in about equal numbers, and no significant differences were detected. No pelagic invertebrates were captured in gillnets. In general, fish densities and biomass quantified using bioacoustics fluctuated between sites throughout the seasonal surveys. However, differences between individual shoals and their reference sites were found in many seasons and some patterns were evident within site pairs. In particular, Fenwick Island Shoal and Weaver Shoal exhibited higher nighttime densities and biomass when compared to their reference pairs, and when tests were significant they favored higher estimates at these shoals the majority of the time. Shoal B and D and their reference sites did not exhibit any consistent nighttime pattern of higher estimates throughout the study.

Two consecutive years of fisheries monitoring in Federal waters off the coast of Maryland and Delaware documented that there are significant seasonal variations in species richness and abundances at the shoals and reference sites in this region of the MAB. There were also yearly variations in abundance, but overall the seasonal patterns of species assemblages are consistent and the majority of the species inhabiting the shoals and reference site habitats are seasonal residents. Comparisons between the net and bioacoustic data suggest that pelagic fish are using habitats differently between day and night. Multiple analyses were conducted on the data collected over the two years and from those analyses we conclude that 1) fish and squid occurring in the MAB either have no preference or prefer substrates at uniform-bottom types to sandy shoals during the day, 2) benthic invertebrates have no preferences for shoals over uniform-bottom types during the day, and 3) there are diel (Day/Night) differences in the abundance of pelagic fish using the shoals and reference sites. Theses data suggest fish could be using the adjacent uniform-bottom habitats during the day and move onto the shoals at night to exploit new habitat, in which case shoals could represent an important resource for fish at night.

STUDY PRODUCTS: Slacum, H.W. JR., W.H. Burton, J.H. Volstad, J. Dew, E. Weber, R. Llanso, D.Wong. 2006. Comparisons Between Marine Communities Residing on Sand Shoals and Uniform-Bottom Substrate in the Mid-Atlantic Bight. Final Report to the U.S. Department of the Interior, Minerals Management Service, International Activities and Marine Minerals Division, Herndon, VA. Contract No. 1435-01-02-CT-85060.

H. Ward Slacum Jr. and William H. Burton. Environmental Investigation of the Use of Shoals Offshore Delaware and Maryland by Mobile Benthos and Finfish Species. Presentation given at the Minerals Management Service Offshore Sand Workshop
Thursday, Oct. 23, 2003, University of Delaware.

H. Ward Slacum Jr. and William H. Burton. Environmental Investigation of the Use of Shoals Offshore Delaware and Maryland by Mobile Benthos and Finfish Species. Presentation given at the Tidewater Chapter of the American Fisheries Society Meeting January 2, 2004, Salisbury University.

H. Ward Slacum Jr., William H. Burton, Jon Volstad, Jodi Dew, and Ed Weber. 2005. Differences in Relative Abundance of Marine Guilds Residing on Offshore Sand Shoals and Flat-Bottom Substrates in the Mid-Atlantic Bight. Presentation given at the 2005 Annual Estuarine Research Federation (ERF) Meeting. Norfolk VA.